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Design of Constant Time Overcurrent Relay Single Phase Based on Arduino Uno

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ABSTRACT: This research aiming for build and design a single phase constant time overcurrent relay (COTR) system based on Arduino Uno. COTR is a device protection used for protect equipment electricity from overcurrent. This system designed for working on network single phase electricity with using Arduino Uno as component main controller. Principle COTR's work is measure flowing current through load and decide connection electricity if current exceed the value that has been set in constant time. Design system covering making current sensor circuit, circuit conditioner signals, and control programs on the Arduino Uno. System this expected can become alternative cheap, reliable and reliable overcurrent protection applied to various type burden single phase electricity.

KEYWORDS: Arduino Uno, Constant Time Overcurrent Relay, Overcurrent, Protection, Single Phase.

1. INTRODUCTION

Safety in the electrical circuit has a crucial role in distributing the quality of voltage to the load, because it is an important part needed to reduce the potential for problems in the electrical system. With the application of Arduino-Based Over Current Relay in electrical circuits, it is hoped that as far as possible from various kinds of problems that can interfere with the reliability of the system [1].

Electrical energy plays a big role in almost all human activities from industry to small-scale, namely household use. To meet the reliability and availability of electrical energy distribution, an adequate protection system is needed. This states that the protection system plays a very important role in the distribution of electrical energy, so the protection system that exists, especially at the substation, must have really good reliability, speed, safety and sensitivity. With the existence of protection, the stability in the distribution of electrical energy will be maintained, the protection of the overcurrent relay or also called the overcurrent relay (OCR), which is an overcurrent safety relay that will work because of the overcurrent installed in the high-voltage network, x-medium voltage as well as the safety of the power transformer. Over current relay (OCR) plays an important role in the operation and protection of the electric power distribution system, namely as equipment that signals the presence of an overcurrent that exceeds the setting [2].

2. LITERATURE STUDY

A. Previous Research

There are several references used in the design process of this Arduino Microcontroller-Based Overcurrent Protection Relay. From the research conducted by Aria Kharisma, Galang Nazharullah Department of Electrical Engineering, Samarinda State Polytechnic OVERCURRENT PROTECTION RELAY BASED ON ARDUINO MICROCONTROLLER [3].

From the research conducted by Alfi Syahri, Andik Bintoro entitled MONITORING AND CONTROLLING POWER BASED ON ARDUINO UNO USING PZEM-004T SENSOR. Due to the research conducted by Alfi Syahri, Andik Bintoro Sensor PZEM-004T is an electronic sensor module that has a function that can measure current, voltage, frequency, power, energy and also power factor and this sensor is also equipped with an integrated CT. The PZEM-004T board has approximate dimensions of 3.1 × 7.4 centimeters. The PZEM-004T material is wrapped with a 3mm diameter current transformer coil that can be used for optimal current detection of 100A. The wiring of this module has 2 parts, namely from the wired connected voltage and current inputs, and the wiring of information transmission. Based on needs, this module has a TTL pin board to support information transmission communication between hardware [4].

B. Microcontroller Arduino Uno

Arduino Uno is an ATmega328P IC based microcontroller board. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 16 MHz quartz crystals, USB connections, power plugs, ICSP headers and reset buttons. It contains

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everything needed to support a microcontroller; simply connect it to a computer with a USB cable or turn it on with an AC-to-DC adapter or battery to start using it [5].

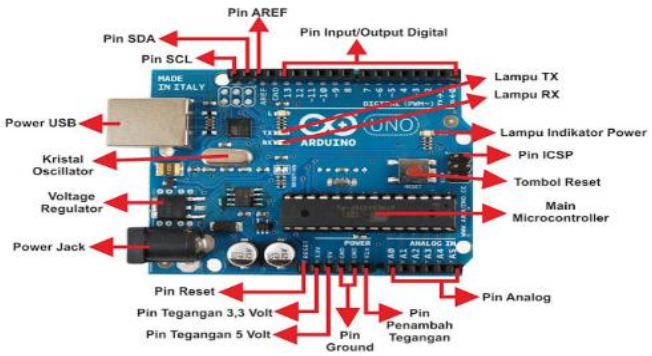

Figure 1. Arduino Uno Shape [4].

C. PZEM 004T

PZEM-004T is a sensor or electrical measurement module that is used to measure various electrical parameters such as voltage, current, power, and energy. This module is often used in DIY (Do It Yourself) projects or energy consumption monitoring applications. PZEM-004T is generally equipped with an LCD screen to display data in real-time and has an output that can be connected with a microcontroller or computer for further data processing. This module can be part of household energy monitoring systems, solar panel monitoring systems, and other applications that require detailed monitoring and measurement of energy consumption [6].

Figure 2. PZEM-004T Sensor [5].

D. Relay

The relay is a switch component that is controlled using electricity and is one of the Electromechanical components consisting of 2 main parts, namely the magnetic coil (coil) and the mechanical part (switch contact). Relays work based on electromagnetic principles to drive their contacts so that only a small electric current *(low power)* can conduct electricity of higher voltage. The shapes and symbols on the relay can be seen below.

Figure 3. Relay [4].

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3. RESEARCH METHODS

A. Time and Location

The time used for this Project Based Learning will be carried out from February 2024 to April 2024 in the Microcontroller Laboratory and Protection Laboratory State Politechnic of Samarinda.

B. Types of Data and Data Sources

The type and source of data used at the time of pre-design is a datasheet or better known as the specification of the component. The types of data sources used during design are books, websites, and journals.

C. System Overview

An overview of the system to be designed on the Arduino-Based PBL Constant Time Over Current Relay Single Phase can be seen in figure 5. The mcrocontroller system gets a voltage supply from a DC power supply of 7.5 – 12 VDC while for the load gets a voltage supply from a 1 phase source on the microcontroller there is 1 Ouput and there are six 3 consisting of 1 push button, current sensor, and relay.

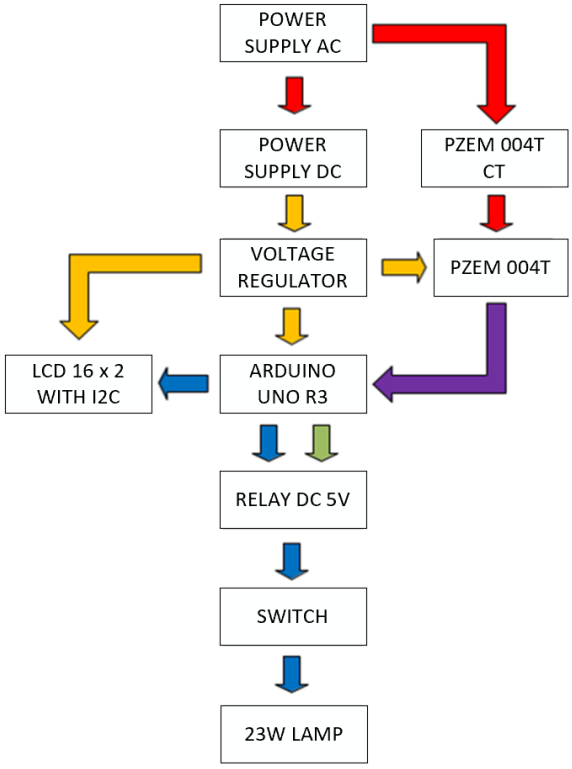

Figure 4. Overview of Arduino-Based Constant Time Over Current Relay Single Phase System.

Based on the system workflow above, it can be described as follows:

1. When the system is on, the sensor will read and display the current value on the LCD.
2. When the sensor reads the value of the overcurrent, more than the set of limited currents, then the Arduino sends a Low signal to the Relay to disconnect the circuit to the load, so that the load shuts off according to the preset time delay.
3. The reset button is used to reset the system in the event of an overcurrent or interruption.
4. To make the system normal, you have to press the reset button, but before pressing the reset button we have to know whether the interference has disappeared or not otherwise the relay will again disconnect so that the load dies.

The Schematic circuit image of the Arduino-Based Constant Time Over Current Relay Single Phase system can be seen in the following figure 5.

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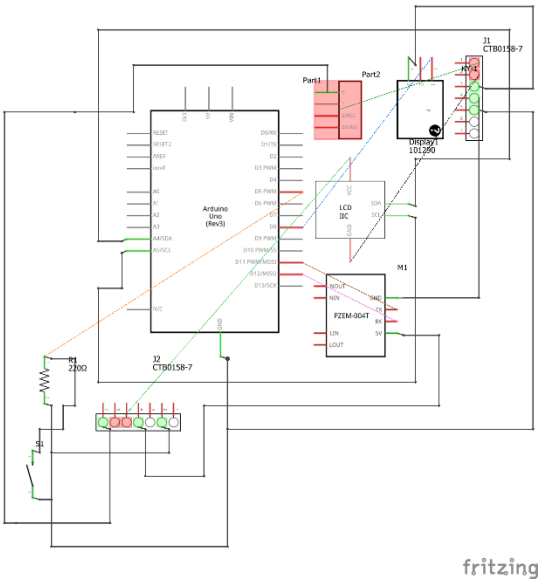

Figure 5. Schematic Diagram of The System.

4. RESULT AND DISCUSSION

A. 16 x 2 LCD with I2C Testing

In the LCD test, we conducted an experiment to see if the LCD could display the words that we had programmed beforehand. Here is a picture of the LCD test results.

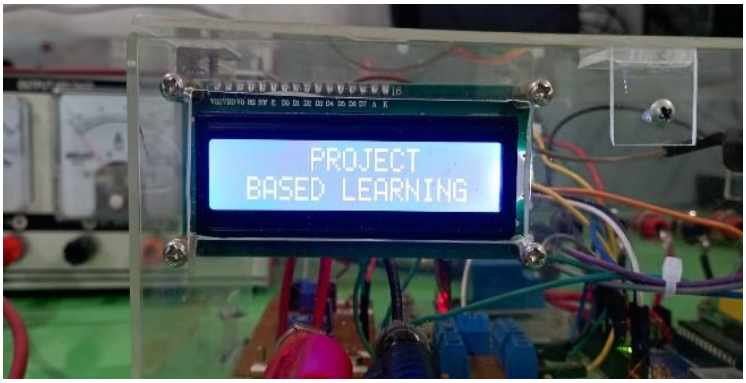

Figure 6. LCD Display When The System Starts On.

Figure 7. LCD Display When The System Starts The Overcurrent Measurement.

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B. Relay Testing

This test aims to evaluate the performance of the 5V relay attached to the Arduino as part of the protection system. The test is carried out to assess the relay's ability to efficiently divert current when detecting potential hazards or disturbances in the system.

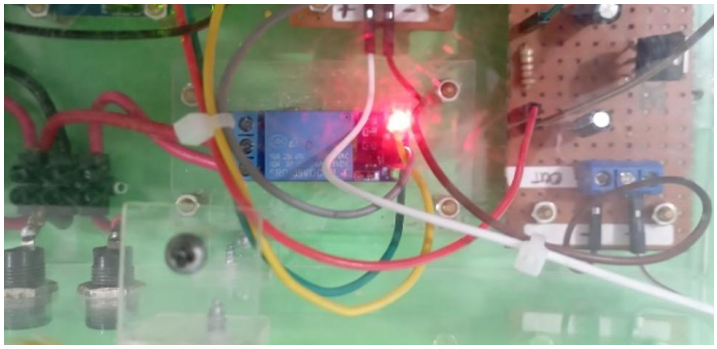

Figure 8. The Relay Works With a Live Red Warranted Indicator Light.

C. PZEM 004T Sensor Accuracy Testing

Before conducting the test, it is necessary to carry out a calibration process so that the current value produced by the current sensor is in accordance with the actual current value. In this testing process, an ampere meter is used as a comparison of the current value produced by the current sensor, this test is carried out ten times with different current values.

Table 1: Result of current measurement using PZEM 004T sensor and multimeter

Number	Current (A)	Current at PZEM 004T (A)	Error	Error (%)
1	0,22	0,23	0.01	0.73
2	0,24	0,25	0.01	0.71
3	0,26	0,27	0.01	0.69
4	0,28	0,29	0.01	0.68
5	0,3	0,31	0.01	0.66
6	0,32	0,33	0.01	0.64
7	0,34	0,35	0.01	0.62
8	0,36	0,37	0.01	0.60
9	0,4	0,41	0.01	0.57
10	0,42	0,43	0.01	0.55
Average error			0.01	0.64

D. Overall System Testing

In this test, the time to delay the relay shutdown at the time of the interruption is 10 seconds with the aim of seeing if the system is really down when given a 10-second delay and also to facilitate data retrieval.

Table 2: System Test Result.

Number	Current (Ampere)	Trip Time (Seconds)	Trip Time in ETAP (Seconds)
1	0,23	10	11
2	0,235	10	11
3	0,24	10	11
4	0,245	10	11
5	0,25	10	11

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6	0,255	10	11
7	0,26	10	11
8	0,265	10	11
9	0,27	10	11
10	0,275	10	11
11	0,28	10	11
12	0,285	10	11
13	0,29	10	11
14	0,295	10	11
15	0,3	10	11
16	0,305	10	11
17	0,31	10	11
18	0,315	10	11
19	0,32	10	11
20	0,325	10	11
21	0,33	10	11
22	0,335	10	11
23	0,34	10	11
24	0,345	10	11
25	0,35	10	11
26	0,355	10	11
27	0,36	10	11
28	0,365	10	11
29	0,37	10	11
30	0,375	10	11
31	0,38	10	11
32	0,385	10	11
33	0,39	10	11
34	0,395	10	11
35	0,4	10	11
36	0,405	10	11
37	0,41	10	11
38	0,415	10	11
39	0,42	10	11
40	0,43	10	11
Average Trip Time			11

In this test, 40 data with different currents were taken. In this system, the smallest current read by the sensor is 0.23 A with a lamp load of 100 Watts with a maximum current limit that can be carried out by a lamp load of 100 Watts is 0.44 A with the following formula.

$$A = \frac{W}{V}$$

Information:
A = Current
V = Tegangan
W = Power

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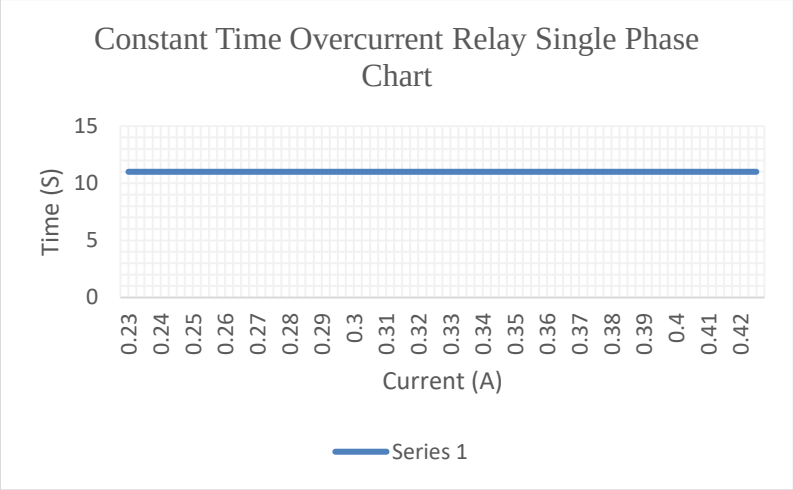

Figure 9. Constant Time Overcurrent Relay Single Phase Chart.

In the graph above, you can see the disconnection time at the time of overcurrent disruption, which is 11 seconds, this is due to the lack of materials in data collection such as programs and tools in taking accurate data.

5. CONCLUSIONS AND SUGGESTIONS

Based on the results that have been obtained in the implementation of the Arduino Uno-Based Constant Time Overcurrent Relay Single Phase Design, it can be concluded as follows:

1. Based on the results that have been obtained, this tool works well even with a presentation error of 0.64%
2. In this experiment the sensor was integrated with an Arduino, a relay and an LCD
3. In this experiment the LCD plays the role of displaying the current detected by the sensor and the relay is used to disconnect the electrical current to the load in case of interference or overcurrent
4. This this system can work optimally and can be relied on
5. This system can be developed by adding iot components such as ESP 32 to perform remote monitoring in real time.

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